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Research Article

Perceptions and awareness of invasive species in the Brazilian Federal District: implications for controlling the giant African snail (*Lissachatina fulica*)

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Abstract

The giant African snail (*Lissachatina fulica*) is among the world's most damaging invasive species, threatening biodiversity, agriculture, and public health. Effective management requires understanding public perceptions, awareness, and engagement, yet sociodemographic drivers of these remain understudied. Here, we evaluate how education, age, and awareness influence attitudes toward *L. fulica* and its management in the Brazilian Federal District. Using structured questionnaires from 613 respondents, we assessed: (1) sociodemographic correlates of perceived knowledge on invasive species, (2) public perceptions and attitudes of invasive species in general and specifically towards *L. fulica*, and (3) evaluation of trust in governmental communication and management efforts. Older and more educated individuals exhibited significantly greater awareness of invasive species and *L. fulica* specifically. However, while higher awareness predicted more negative perceptions of the snail, it did not correlate with proactive control behaviors. Public satisfaction with government management efforts was strongly tied to self-reported knowledge of the snail's impacts, highlighting a gap between awareness and actionable responses. Our results underscore the need for targeted outreach programs prioritizing younger and less-educated demographics. We propose that generalized education on biological invasions can bolster the success of species-specific campaigns. These insights are critical for designing inclusive policies that enhance community participation in *L. fulica* management, offering a model for engagement in regions facing similar invasion challenges.

Key words: Biological invasions, community engagement, environmental education, exotic species, invasive species management, policy implications, public perception, sociodemographic factors

Introduction

Biological invasions, defined as the introduction and establishment of species beyond their native ranges, constitute a significant and escalating challenge to global biodiversity and ecosystem integrity (Pyšek et al. 2020). The rising frequency and magnitude of these invasions are solely driven by human activities, particularly global trade, transportation, and land-use change, which facilitate the movement of organisms across natural biogeographical barriers (Seebens et al. 2017). Invasive

species can profoundly impact native ecosystems by reducing biodiversity, altering habitat structure, and driving local extinctions (Vilà et al. 2011). The economic consequences are also severe, with substantial losses reported in agriculture, forestry, and fisheries, and global costs estimated to reach billions of dollars annually (Diagne et al. 2021). Furthermore, invasive species can pose threats to human health by serving as vectors for diseases or eliciting allergic reactions (Pyšek and Richardson 2010). Given these wide-ranging ecological, economic, and social impacts, understanding the processes underlying biological invasions and the public's perceptions of these issues is crucial to formulate effective management and policy responses.

Urban environments face particular susceptibility to biological invasions due to habitat disturbance, high propagule pressure, and resource availability (Gaertner et al. 2017). Although integrated management approaches - combining mechanical, chemical, and biological controls have been developed to mitigate these invasions (Kenis et al. 2017, Sobuj and Byun 2023), their success hinges on community engagement (Carter et al. 2021). Understanding public perceptions of invasive species is therefore critical, as it directly informs management strategies and policy design. Specifically, assessing how demographic groups perceive invasive species threats, their willingness or oppose to participate in control efforts, and their awareness of management protocols can help align scientific recommendations with on-the-ground implementation.

Public awareness and perceptions of invasive species are shaped by a complex interplay of psychological, ecological, and sociocultural factors (Shackleton et al. 2019a; Carter et al. 2021). Awareness denotes the recognition and understanding of the presence and impacts of invasive species, often assessed by the ability to identify them and articulate their effects (Eiswerth et al. 2011; Jubase et al. 2021). Perception refers to how people react to invasive species, encompassing their attitudes, judgments, and behavioral intentions (Kapitza et al. 2019; Shackleton et al. 2019a). Broader sociocultural and institutional contexts, such as local environmental policies, further modulate these perceptions (García-Llorente et al. 2008; Kapitza et al. 2019; Shackleton et al. 2019b). Divergent views among stakeholders can lead to societal conflicts (Shackleton et al. 2019c; Carter et al. 2021), which may ultimately undermine invasive species management and control efforts (Sharp et al. 2011).

The giant African snail (*Lissachatina fulica*), ranked among the world's 100 worst invasive species (Lowe et al. 2000), exemplifies these challenges. Native to East Africa, it has been intentionally or accidentally introduced across tropical and subtropical regions globally, causing significant agricultural damage (Raut and Ghose 1984; Kant and Diarra 2016) and posing public health risks (Alves-Barbosa et al. 2020, Aguilera and Ortiz 2019). Control measures in Neotropical regions include manual collection and chemical agents (e.g., calcium oxide, metaldehyde baits) (Thiengo et al. 2007; MAVDT 2011; Ramdwar et al. 2018), as well as plant-derived alternatives (Roda et al. 2018 2019). However, *L. fulica* thrives in urban areas–residential gardens, vacant lots, and backyards (Albuquerque et al. 2008)–making community participation essential for effective management. Public perception of the species thus plays a pivotal role in shaping control outcomes.

Regional case studies highlight how sociocultural contexts influence *L. fulica* management. In Cuba, where the snail was introduced for religious purposes, communities recognize disease risks but struggle with control compliance (Vázquez et al. 2017; Meijides-Mejías et al. 2018). In Colombia, where the mollusc was presumably introduced for economic reasons, a systematic collection framework

was established a few years after its introduction. However, concerns regarding parasitic contamination associated with handling the snails have impeded effective management initiatives, as individuals are often reluctant to participate in manual collection due to fears of infection (Patiño-Montoya et al. 2019). In Brazil, where the species has been established for over 30 years (Colley and Fisher 2009; Andreazzi et al. 2017), perceptions remain predominantly negative (Colley and Fisher 2009). Such variability complicates management efforts across invaded regions.

In this study, we explored the characteristics, perceptions, and awareness of residents in Brazil Federal District to support *L. fulica* management. Specifically, we (1) examined whether sociodemographic factors correlate with perceptions and self-reported knowledge of invasive species in general and specifically towards *L. fulica*, (2) investigated how perceptions and awareness of invasive species relate to those of *L. fulica* and attitudes toward its control; and (3) evaluated how these factors influence public trust in governmental communication and management efforts. By addressing these questions, we aim to guide policy development, mitigate public resistance, and foster collaborative strategies for *L. fulica* control.

Methods

The Brazilian Federal District, encompassing the capital city Brasília, is a unique administrative entity with a distinct demographic profile. With an estimated population nearing 3 million in 2024, the Federal District is one of Brazil's most urbanized areas and holds the highest Human Development Index (HDI) in Brazil. According to the Brazilian Institute of Geography and Statistics, the population comprises 48% men and 52% women. Age distribution is as follows: 26% younger than 20 years, 33% between 20 and 39 years, 28% between 40 and 59 years, 11% between 60 and 79 years, and 2% aged 80 years or older. Educational attainment is relatively high: 26% of the population have completed or are currently pursuing basic education, 37% completed secondary education but not higher education, and 33% hold a university degree. This socio-economic profile is shaped by its role as the nation's political and administrative center, which attracts a highly skilled workforce and sustains a robust service sector.

Sampling

We developed a structured questionnaire based on the framework of Patiño-Montoya et al. (2019), comprising three sections (Table 1). The first gathered data on residence location, gender, age, and education level. The second section explored general perceptions and awareness of invasive species, their impacts, control measures, and reporting protocols. The third section explored experiences with *L. fulica*, its control, and perceptions of its impacts. The questionnaire was linguistically and culturally adapted for the Brazilian Federal District by the Environmental Agency (Instituto Brasília Ambiental–IBRAM). It included binary (Yes/No) and Likert-scale responses (1–10) and was hosted online (Google Forms) via the IBRAM website (https://www.ibram.df.gov.br) from May to September 2019.

To ensure sociodemographic representation, we supplemented online responses with in-person interviews using printed questionnaires across diverse regions of the Federal District. During the in-person interviews, participants were first asked whether they were interested in taking part in our study on invasive species. Those

Table 1. Questionnaire applied to residents of the Federal District, Brazil (May–September 2019).

1. Sociodemographic Information
Region of residence, Gender, Age, and Education
2. Invasive species
(A) Have you heard of invasive species? (yes/no)
(B) Do you believe that invasive species can have negative effects? (yes/no)
(C) Have you ever noticed a possible invasive species in your home? (yes/no)
(D) Do you know what to do if you find an invasive species in your home? (yes/no)
(E) Do you know to which authority to report on the occurrence of invasive species? (yes/no)
3. Giant African Snail *L. fulica*
(F) How much do you know about the Giant African Snail? (1–10)
(G) Have you heard about parasites in the Giant African Snail? (yes/no)
(H) Have you personally seen a Giant African Snail? (yes/no)
(I) Have you personally collected a Giant African Snail? (yes/no)
(J) How harmful is the Giant African Snail to the environment? (1–10)
(K) How harmful is the Giant African Snail to public and animal health? (1–10)
(L) Do you know control measures for the Giant African Snail? (yes/no)
(M) How good is the government authority in providing information about the Giant African Snail and controlling it? (1–10)

who agreed received a printed questionnaire and completed it on-site, without any interaction with or observation by the interviewer, except when the interviewed person was unable to read. The minimum sample size was calculated based on the population of the Federal District in 2019, using a 95% confidence level and a 5% margin of error, following the methodology described in Monte de Sena (2005).

Due to support from the Instituto Brasília Ambiental (IBRAM) and the University of Brasília (UnB), it is possible that online respondents were more likely to have higher education levels and a greater interest in environmental issues. To mitigate this potential bias, we encouraged secondary sharing of the online survey through social networks (i.e., friends of friends) and conducted in-person surveys at locations where people from all regions of the Federal District converge (e.g., the main bus station). Additionally, we continuously monitored the geographic distribution of responses to prevent overrepresentation from any particular region. Whenever an administrative region reached a number of responses disproportionate to its population size, we paused data collection in that area and intensified efforts in underrepresented regions to ensure balanced sampling.

Data analysis

Initially, we conducted a comprehensive analysis of all questionnaire responses using descriptive statistics. To examine how sociodemographic factors relate to perceptions and awareness of invasive species and *L. fulica*, we employed permutation Fisher's exact tests, grouping numerical responses (1–10) into low (1–3), medium (4–7), and high (8–10), and dividing age into 11–37 and 38–83 years, according to the mean age. This approach allowed us to evaluate frequency deviations in perceptions and awareness of invasive species, *L. fulica*, as well as the inclination to control it. We then used multiple correspondence analysis (MCA) with the FactoMineR (Le et al. 2008) and factoextra (Kassambara and Mundt 2020) packages

to assess how perceptions and awareness of invasive species (Section 2) relate to those of *L. fulica* and attitudes toward its control (Section 3). Lastly, we employed a negative binomial generalized linear model (GLM) to test how these perceptions influence public evaluation of governmental communication and control efforts regarding *L. fulica*; the significance of model terms was assessed with the Analysis of Deviance (Type II Wald chisquare test), and model validity was evaluated using a Kolmogorov-Smirnov goodness-of-fit test, an overdispersion test, and an outlier test, all with the DHARMa package (Hartig 2018). All analyses were conducted in R v.3.6.3 (R Core Team 2020).

Results

Our survey included 613 respondents from all regions of the Federal District, with 423 participating online and 190 in person (Suppl. material 1: table S1). The sample showed a balanced gender distribution (42% men, 57% women, 1% not stated) and encompassed a broad range of education levels, albeit with a slight overrepresentation of highly educated individuals: 28% had basic education completed or in progress, 32% were undergraduates, and 40% held graduate degrees. The mean age was 38.9 years (SD = 16.1; range: 11–83). Overall, this distribution was broadly consistent with the sociodemographic profile of the Federal District.

Most participants had heard of invasive species (79%), believe that they can have negative effects (88%), and reported observing invasive species in their homes (53%). Nonetheless, the majority were unaware of appropriate actions to take if an invasive species is found (75%) or which agency to contact for assistance (80%). Regarding *L. fulica*, 51% of respondents reported low familiarity (scores 1–3 out of 10), yet 41% and 48% rated its environmental and health impacts as high (scores 8–10), respectively. Although 58% had encountered the snail and 32% had collected it, only 16% understood control methods. Public dissatisfaction with management was evident: 59% rated governmental information as inadequate (scores 1–3), and 75% deemed control efforts insufficient.

Our analysis revealed significant associations between sociodemographic variables and responses from both survey sections. Education level showed the strongest effect (Fisher's exact test, $P < 0.001$), with higher education correlating with: (1) greater awareness of invasive species generally, (2) better perceived knowledge of *L. fulica* specifically, and (3) increased understanding of control measures. Age also significantly influenced responses ($P < 0.002$), as older respondents - particularly those with higher education - were more likely to perceive invasive species as a serious threat and recognize the need for snail control. While gender differences were less pronounced, men demonstrated slightly greater awareness of reporting authorities for invasive species ($P = 0.008$). Notably, evaluations of governmental performance in *L. fulica* management showed no significant association with any sociodemographic factor ($P > 0.05$).

Multiple correspondence analysis revealed two distinct dimensions of public responses (Fig. 1). The primary dimension, accounting for 32% of the variance, demonstrated a strong association between general perceived knowledge of invasive species and specific self-reported familiarity with *L. fulica* and its impacts. This dimension encompassed factual awareness (items A, F, G, H), self-reported knowledge and risk judgments (items B, J, K). The secondary dimension (14%) isolated procedural knowledge related to management actions (items D, E, L),

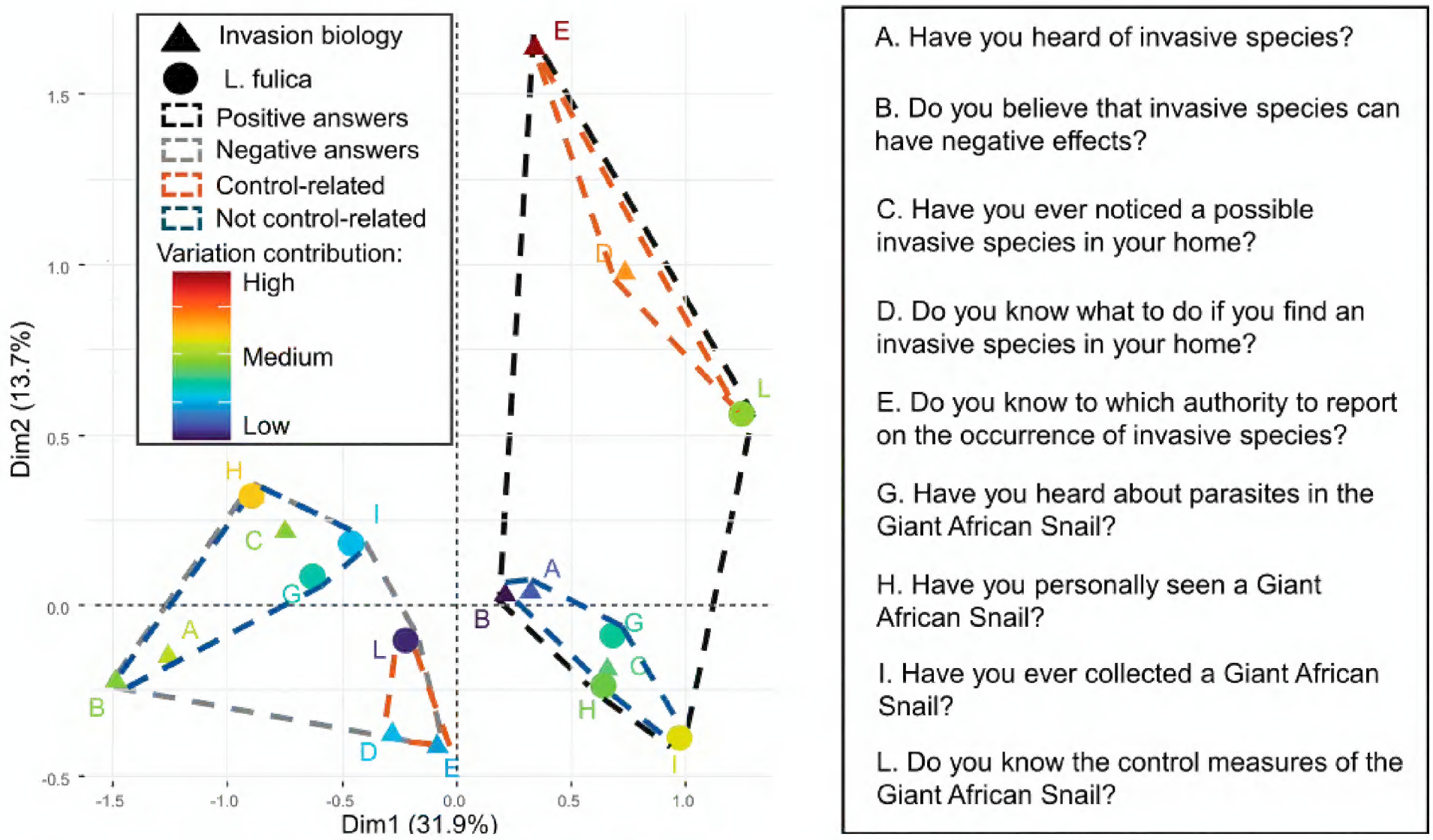
Invasion biology
L. fulica
Positive answers
Negative answers
Control-related
Not control-related
Variation contribution:
High
Medium
Low
Dim2 (13.7%)
Dim1 (31.9%)
A. Have you heard of invasive species?
B. Do you believe that invasive species can have negative effects?
C. Have you ever noticed a possible invasive species in your home?
D. Do you know what to do if you find an invasive species in your home?
E. Do you know to which authority to report on the occurrence of invasive species?
G. Have you heard about parasites in the Giant African Snail?
H. Have you personally seen a Giant African Snail?
I. Have you ever collected a Giant African Snail?
L. Do you know the control measures of the Giant African Snail?

Figure 1. Multiple correspondence analysis (MCA) of public awareness and perceptions regarding invasive species (triangles) and *Lissachatina fulica* (circles) in Brazil's Federal District. Dim.1 (x-axis, 32% variance) shows a positivity gradient ("No" [left] to "Yes" [right] responses), while Dim.2 (y-axis, 14% variance) shows that control-related items (D, E, L) diverge from the remaining perceptions and attitudes. Colors reflect each answer's contribution to total variance (warmer hues = higher contribution). Letters refer to questionnaire items (Table 1).

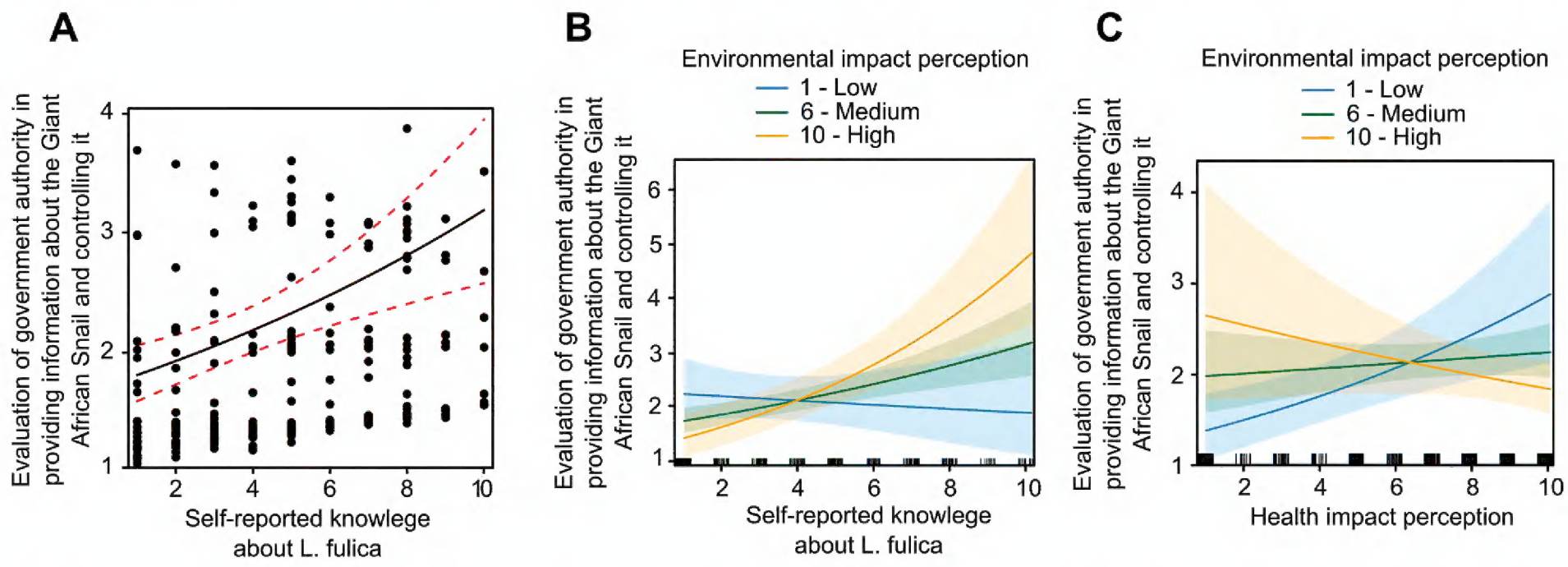

Figure 2. Public evaluations of government management actions for *Lissachatina fulica* in relation to: **A.** Self-reported knowledge; **B.** Interactions between self-reported knowledge and environmental impact perception; **C.** Interactions between environmental and health impact perceptions. Three constant values of environmental impact perception were set to illustrate the interactions among variables: low (blue line with #1), medium (green line with #6), and high (yellow line with #10).

indicating that apparent knowledge of what to do, whom to contact, and how to control invasive species constituted an independent component, distinct from general species knowledge and impact assessments.

Self-reported knowledge about *L. fulica* significantly influenced evaluations of government management actions (χ^2 = 29.90, df = 1, P < 0.001; Fig. 2A). This relationship was moderated by environmental impact awareness, with a significant interaction effect (χ^2 = 7.00, df = 1, P = 0.008; Fig. 2B). Specifically, respon-

dents reporting medium to high environmental impact awareness (scores 6-10) demonstrated a positive association between *L. fulica* perceived knowledge and government performance ratings. We also found a significant interaction between environmental and health impact awareness on government evaluations ($\chi^2 = 8.39$, df = 1, P = 0.004; Fig. 2C). The pattern revealed three distinct response levels: (1) lowest ratings from respondents unaware of both impacts, (2) highest ratings from those aware of either environmental or health impacts, and (3) intermediate ratings from individuals aware of both impact types (Fig. 2C).

Discussion

Education and age influence perceptions and awareness of invasive species and *Lissachatina fulica*

Our study confirms that higher education levels correlate with greater awareness of invasive species, including *L. fulica* (giant African snail). This aligns with prior research indicating that formal education enhances environmental literacy and informed decision-making (Eiswerth et al. 2011; Cordeiro et al. 2020; Melo et al. 2021). Age also played a significant role, with older individuals expressing stronger concern about invasive species and the snail, mirroring findings from Colombia (Patiño-Montoya et al. 2019) and studies on invasive plants (Potgieter et al. 2019). These results suggest that both education and age are critical predictors of public engagement in invasive species management, reinforcing the need for targeted environmental education across different demographic groups.

Notably, our findings indicate that a greater proportion of participants attributed negative impacts to invasive species (88%) than those who reported prior familiarity with the term "invasive species" itself (79%). This discrepancy suggests that, even in the absence of explicit conceptual understanding, respondents may infer detrimental consequences from the semantic connotation of the word "invasive," which inherently evokes notions of harm, threat, or disruption. The negative valence associated with this terminology has been widely documented in the literature, with studies demonstrating that the language employed in invasion biology, often characterized by militaristic or alarmist metaphors, can shape public perceptions and attitudes toward these organisms (Janovsky and Larson 2019). Thus, the framing of invasive species in both scientific and popular discourse may contribute to the intuitive association between unfamiliar species and negative ecological or societal outcomes, independent of respondents' formal knowledge or direct experience.

Perception and awareness of invasive species are linked to perception and awareness of *Lissachatina fulica* but not to control

Multivariate analysis revealed that individuals who understand invasive species as a concept are more likely to recognize *L. fulica* as a threat. However, awareness alone does not guarantee control behaviors, likely due to competing personal values, emotional responses, or direct experiences (e.g., property damage). As Shackleton et al. (2019a) observed, practical concerns (e.g., garden destruction) often drive action more than ecological awareness. Thus, effective management strategies should combine general environmental education with behaviorally targeted interventions, addressing both ecological, personal, and economic motivations for control.

Although public awareness of invasive species is often high, this knowledge seldom translates into effective management actions, resulting in a persistent knowledge–action gap observed not only in invasion biology but also in climate change and other environmental challenges (Esler et al. 2010; Golebie et al. 2025). Theories such as the value–action gap and the limitations of the information-deficit model suggest that knowledge alone is insufficient; psychological, social, and structural barriers, including lack of self-efficacy, unclear institutional responsibilities, and low perceived benefits, often prevent action (Kollmuss and Agyeman 2002; Lauren et al. 2016). In the case of *L. fulica*, the problem is not a lack of scientific information. Latin America, especially Brazil, has generated substantial research over the past two decades (Thiengo et al. 2007; Vogler et al. 2013; Patiño-Montoya et al. 2019; Marins et al. 2023; Silva et al. 2024). Instead, much of this knowledge is fragmented and not oriented toward practical management, complicating its interpretation and application by stakeholders (Cooke et al. 2021). To overcome this gap, we advocate for a paradigm shift toward co-producing actionable knowledge with stakeholders and creating real incentives, so that individuals recognize tangible benefits and improved quality of life when engaging in invasive species management (Cooke et al. 2021).

Self-reported knowledge about *Lissachatina fulica* influences evaluation of government actions

Respondents with greater self-reported knowledge of *L. fulica* tended to rate government actions more favorably, supporting studies that link environmental literacy to policy support (Marquart-Pyatt 2018; Wang et al. 2023). Interestingly, those aware of only one aspect of the snail's impact (either ecological or health-related) gave higher approval ratings than those recognizing both threats. This suggets that perceiving multiple threats may foster more critical assessments of government performance. Future research should explore this paradox to optimize public awareness campaigns and policy communication.

We acknowledge that our study has certain limitations. First, our survey measured respondents' self-reported confidence in their knowledge without directly verifying its accuracy. This limitation is illustrated by findings from the state of Paraná, where half of the respondents failed to correctly identify *L. fulica* (Simião and Fischer 2004). Second, the survey was conducted during the dry season, when snails are typically aestivating underground and thus less visible, which may have affected participants' interest and engagement. Third, there is a potential bias toward respondents with higher educational attainment, possibly accounting for the elevated confidence levels observed. Despite these constraints, our results yield important insights into public perceptions and behaviors regarding invasive species, which are valuable for informing management strategies and guiding the development of effective public policies.

Conclusions

Our findings highlight key demographic and cognitive factors influencing public perception, awareness, and management of *L. fulica* in Brazil's Federal District. Older and more educated individuals exhibited greater awareness, underscoring the need for expanded outreach to younger and less-educated groups to

ensure broad societal engagement. While awareness of invasive species correlates with recognition of *L. fulica* as a threat, knowledge alone is insufficient to drive control behaviors.

To improve invasive species management, we recommend integrated education campaigns that combine ecological literacy, defined as the ecological knowledge necessary for a person's decision-making, with practical control methods to bridge the gap between awareness and action. Additionally, enhancing policy transparency and evaluation by clearly communicating government efforts and incorporating community feedback will strengthen public trust and adaptive management. By aligning scientific knowledge, public education, and policy actions, it is possible to enhance invasive species control while fostering long-term community participation in ecological stewardship.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Patiño-Montoya A. Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review and editing. Marins G. Data curation, Formal analysis, Methodology, Writing – review and editing. Nomiyama TS. Conceptualization, Data curation, Investigation, Writing – review and editing. Rosana Tidon. Conceptualization, Funding acquisition, Investigation, Supervision, Writing – original draft, Writing – review and editing.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

Survey Dataset of 613 Residents in the Brazilian Federal District on Biological Invasions, the Giant African Snail and its control

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Data type: xlsx

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